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Mississippi State University

Center for Air Sea Technology

1993 STUDENT RESEARCH PROJECTS

Technical Note 02-94
31 December 1993

Prepared for: Office of Naval Research (Code 1242)
Under Research Grant N00014-92-J-4109

Mississippi State University Center for Air Sea Technology
Stennis Space Center, MS 39529-6000

MISSISSIPPI STATE UNIVERSITY
CENTER FOR AIR SEA TECHNOLOGY

1993
STUDENT RESEARCH PROJECTS

BUILDING 1103-ROOM 233

STENNIS SPACE CENTER, MS 39529-6000

Compiled and Edited by
Lanny A. Yeske

This research was supported by the Department of the Navy, Office of the Chief of Naval Research, under Contract/Research Grant Number N00014-92-J-4109. The information contained in this publication does not necessarily reflect the position or the policy of the United States Government. No official endorsement should be inferred.

FOREWORD

The Center for Air Sea Technology was established in October 1992 and evolved from the Experimental Center for Mesoscale Ocean Prediction (ECMOP), initially developed by the Institute for Naval Oceanography. The system software that originally comprised ECMOP now consists of the CAST Model Evaluation System (CMES), the Interactive Data Editing and Analysis System (IDEAS), and the Data Search System (BROWSER). The Center's objectives are:

- To develop the capability in the CMES to support the research associated with air-sea models and prediction systems during all stages of development;
- To transition all or portions of these newly developed capabilities toward operational application within the Navy, academia, and industry;
- To conduct research and development of next generation models and support capabilities;
- To maintain a state-of-the-art computational environment for model development; and
- To strengthen collaboration with academia by incorporating students and faculty in CAST projects.

In accomplishing the last objective, CAST in 1993 supported 11 graduate and undergraduate students, which included four students through the MSU Cooperative Education Program, three from the MSU Department of Computer Science, and one student each from the MSU NSF-sponsored Engineering Research Center, the University of Southern Mississippi, Tulane University, and Louisiana Tech University. CAST also had a faculty program with four research affiliates from the MSU and Tulane University Departments of Computer Science, as well as the Engineering Research Center.

This technical note summarizes the 1993 research conducted by these students and research affiliates. CAST was extremely pleased with the research support provided by these individuals, not only in their dedication but in the quality of the research conducted.

J.H. CORBIN
CAST Director

1993 SUMMER RESEARCH PROJECTS

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Patrick Perrin
M.S. Program, Department of Computer Science
Tulane University

Title: Knowledge Discovery and Information Retrieval in Large Numerical Databases - An Application to Ocean Modeling

Objectives: Environmental numerical databases (oceanographic and atmospheric) are expanding so fast that methods to intelligently analyze and present the raw data have to be developed. This research involves developing a CAST Intelligent Support System (CASTISS) to explore large databases. The motivation is that actual query languages do not provide the user efficient tools to automatically and systematically analyze the knowledge contained in the database in order to retrieve what best suits the user's interests. When using databases, it is usually not feasible to browse the entire database in making correlations between all objects to find everything related to his current interests. This study is directed to solving the two main problems of an intelligent support system: knowledge discovery and information retrieval in large databases.

Approach: One approach of knowledge discovery in numerical databases is to study the statistical behavior of the objects of a dataset to find interesting relationships. This is accomplished by using unsupervised machine learning techniques, such as multivariate data analysis to find "structure" in the data. Objects presenting similar features, or structure, are then grouped together in the same cluster. Applying clustering techniques to ocean modeling and prediction data allows data extrapolation to predict future events.

Since it is always possible to discover "something" in numerical databases, "interesting" findings must be determined in correlation with the user's interests. This is done by using data mining techniques, such as semantic query optimization for information retrieval. This allows one to analyze the user's query to determine and then retrieve any interesting features.

The design of the main functional components of the CASTISS is shown in Figure 1.

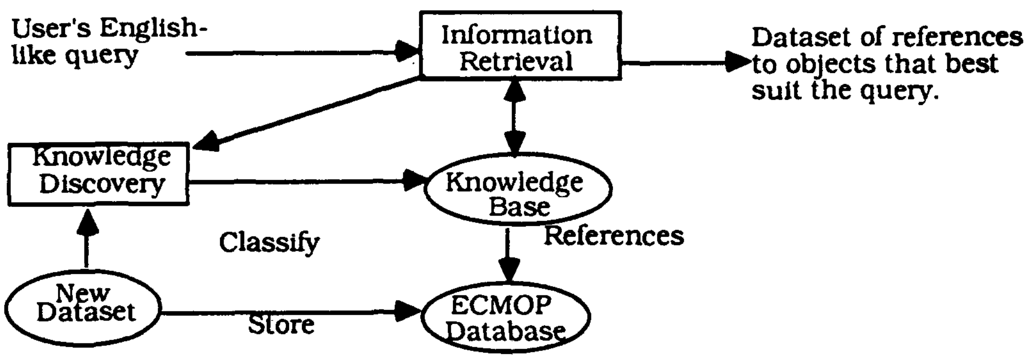

Figure 1. CAST Intelligent Support System Functional Description

As part of the information retrieval module, the query processing module is intended to define and refine the user's query as well as to determine the application domain in which features to discover could be of interest. This is done in an interactive and intelligent user-friendly dialogue. Also, as part of the information retrieval module, the data mining module searches in the knowledge base for the dataset of objects that best suit the user's needs. The search could be refined in an interactive dialogue by presenting to the user and interpreting the dataset found.

The selected dataset of objects is composed of references to the real objects stored in the database. Such dataset may then be used for other applications, such as the CMES and IDEAS, an application for the editing and analysis of ocean temperature and salinity profiles. The

knowledge base contains the representation of the semantics of the domain of application, which is the oceanography for our case study. It also contains the relationships among objects and/or features that were determined during the knowledge discovery phase.

Since the environmental numerical databases contain a huge amount of daily increasing information (order of Terabyte per day), knowledge discovery can be made at two different but complementary,levels. First, as a preprocessing step on every new set of raw data that has to be ingested in the database. Some predefined data analyses are performed on the dataset to discover interesting relationships between features among the objects of the dataset and also in relation to the other objects already classified in the knowledge base. Clustering techniques appear promising in discovering knowledge in the CAST database. Secondly, knowledge discovery can be made when searching the knowledge base to satisfy the user's query. This is termed data mining and which we believe can be done efficiently and effectively by semantic query optimization and by searching for already discovered findings in the knowledge base. If no "interesting" findings are present in the knowledge base, data mining using knowledge discovery techniques can be done for these particular needs requested by the user. Research is still in process to implement and test this approach.

The CAST database is composed of four generic data types consisting of satellite image, latitude-longitude-time (LLT), line, and grid. This study focuses on the grid data type. Grid data contain atmospheric and oceanographic numerical model outputs, user-defined products, and gridded climatology data. Each grid is stored in the database by a field, and a grid database object is uniquely identified.

Our approach, instead of trying to cluster the entire database and attempting to find all possible relationships between every pairs of objects, is to use only some predefined interesting analyses. These are determined by the analysts according to the application domain, which guides the discovery in this phase. This is justified by the fact that we know in advance some correlations between concepts are not of interest for the application domain, and thus trying to discover patterns in them will be fruitless. This also alleviates the problem of deciding which features are interesting to cluster. As noted earlier, clustering everything is time consuming and irrelevant for the intended application or the knowledge. For example, clustering grid data on their model and version (i.e., trying to find something interesting on the correlation of the model and its version) has no use for the oceanographic community.

To develop a first prototype, we used the clustering package designed by Yoshiro Miyata and Andreas Stolcke, Cluster 2.3. As an example, consider a research team is running sound tracks near Florida and would like to know how uniform the sound speed is in the Gulf Stream at various depths on 12 July 1991. The high-level query from the CASTISS is: "What information do you have on sound speed on 12 July 1991 in the Gulf Stream near Florida at a depth of 50 meters?" The query processing module transforms this to define a knowledge profile, and then the data mining module searches for a cluster containing this profile. The knowledge that corresponds to that profile is a cluster tree, from which the scientist may study the sound speed uniformity.

Results: The first prototype of CASTISS shows that knowledge discovery in the CAST database is feasible and promising, despite the fact that some approaches have to be refined.

Future Research: The ultimate goal is to build CASTISS for scientific use. Future plans call for further development of the prototype information retrieval system (query processing and data mining), refining the data clustering process by including the Cluspak clustering package, and fully developing the domain knowledge with the assistance of oceanographic analysts.

Research Advisor: Dr. Fred Petry, Department of Computer Science, Tulane University

Zhifan Zhu
Ph.D. Program, Engineering Research Center
Mississippi State University

Title: Enhancing the Visualization Capabilities of the CAST Model Evaluation System (CMES)

Objectives: Ocean physics contains complex processes that evolve over both space and time, and exhibit many dynamic mesoscale features such as eddies and fronts. Studying the evolution, deformation, and interaction of these features and accurately modeling them is important oceanographic research. In investigating these features, a vast volume of data is collected or model generated.

Scientific visualization provides an effective means for scientists to study the evolution and interaction of these features over large time varying periods. It works by converting data volumes from numerical solutions into graphical images that are easily understood. The goal of oceanographic visualization is for scientists to accurately track features such as eddies and fronts, and therefore build and validate their mathematical models. Many visualization techniques have been found effective in providing insight. However, an important visualization need is to automatically recognize and track the underlying features from oceanographic data sets. Unfortunately, little work has been done in this area. Important features not anticipated in large data sets should be detected automatically during the visualization process. This is the typical situation in rendering large four dimensional and multi-parameter data sets. The existence, and therefore the locations of hidden features are unknown even to a knowledgeable user. Without an automatic mechanism, intensive and time consuming searches must be performed, otherwise features may not be revealed. Also, in the analysis of the evolution and interaction of features, their temporal motions and fluctuations and the cross-correlations over multi-parameter fields are best observed continuously through animation. This again aggravates the searching problem. To best characterize the features, locally optimized data classification must be achieved at each time step and depth level for each parameter. It is a difficult task. In this paper, we present the work we have done in addressing feature detection in four dimensional oceanographic visualization.

Approach: Volume visualization is a current fast growing technique. A scalar function $f(x,y,z)$ is defined by a set of discrete samples over a 3D space termed called a volume. Volume visualization allows generating and rendering of imagery presentation by traversal of the data volume. Many algorithms have been developed in this area. All volume rendering techniques must possess the properties of easily understandable graphic presentation and fast data traversal. Another critical point in rendering time varying data volumes is the animation capability.

Although the relative advantages and disadvantages of different volume rendering techniques may vary across scientific domains due to diverse concerns in practical applications, quickly locating and therefore concentrating on the parts of interests in a large data set is preferred. This is a typical situation in oceanographic applications when dynamic ocean features need to be quickly detected and tracked over both space and time.

Visualization in oceanography is a process that helps scientists investigate the behavior of mesoscale ocean features and correctly model them. The steps include understanding, modeling, and predicting. The final goal is to drive the validated models to resolve and predict climatological incidents. Therefore, identifying, locating, and tracking these features from visualization is critical. However, the capabilities of automatic feature extractions are limited in present technology.

The feature extraction algorithm serves as a preprocessor. It should be able to automatically identify and locate the most likely features for the user to visualize. Based on predefined criteria, the algorithm should be able to work independently inside animation procedures, so that the evolution of features and interactions can be easily tracked.

Our research is to develop edge based feature extraction algorithms as applied to oceanographic visualization. Our approach is to apply the 3D edge operator developed in the 3D environment and to develop associated algorithms to extract features and render them with 3D techniques.

To extract features from a noisy data volume, a temporal filter was developed. It takes advantage of the temporal correlations between data volumes. Feature movement along the time axis forms an active region in the 3D space. This region contains all possible motion pa during that time duration. By setting a temporal threshold, the most active feature moving pa can be recognized. All points falling outside this active region can be ignored. This significa reduces the computation load on later edge tracking.

Obviously, it is much more complex to comprehend 3D objects than 2D objects. However, in analyzing oceanographic data sets, strong spatial correlations have been found between horizontal data slices within a data volume. Therefore, recognition and reconstruction of 3D features can be achieved by spatially correlating those pieces of features extracted from 2D data slices. Specifically for an eddy feature, these correlations may include function values, edges, and shapes.

Results: Two schemes were implemented to meet different application requirements regarding accuracy and performance efficiency, since the efficiency of visualization is mostly application dependent. In the first scheme the feature extraction process was simplified and was faster. It assumed that the data volume only contained homogeneous features. That means that all possible features at the same depth would share the same boundary values although their physical shapes differed. It also allowed the function value to change inside a feature. These conditions were found to be true in the Gulf of Mexico temperature test data set. The noise reduction was only done by the temporal correlation filter. Thus the whole feature extraction process was greatly speeded up by finding only the features boundary values globally for each depth level. Figure 1 shows the isosurfaces of temperature.

Figure 1. Isosurfaces of Temperature in the Gulf of Mexico:
(a) without feature extraction, (b) with feature extractions.

Figure 2 displays 11 images of an animated sequence of eddy movements in the Gulf of Mexico. The feature extraction algorithms were applied at each time.

The second scheme seeks to find the exact locations of features by using iteration procedures, and is intended to yield more accurate feature extraction. The output of the algorithm includes both the locations and the boundary values of features. Therefore, it allows completely different feature characteristics. Since animation is not considered a major rendering utility in this case, more user interactive tools are provided. Users can change searching criteria (size and eccentricity) based on how they define the features. Figure 3 shows the extracted eddy feature.

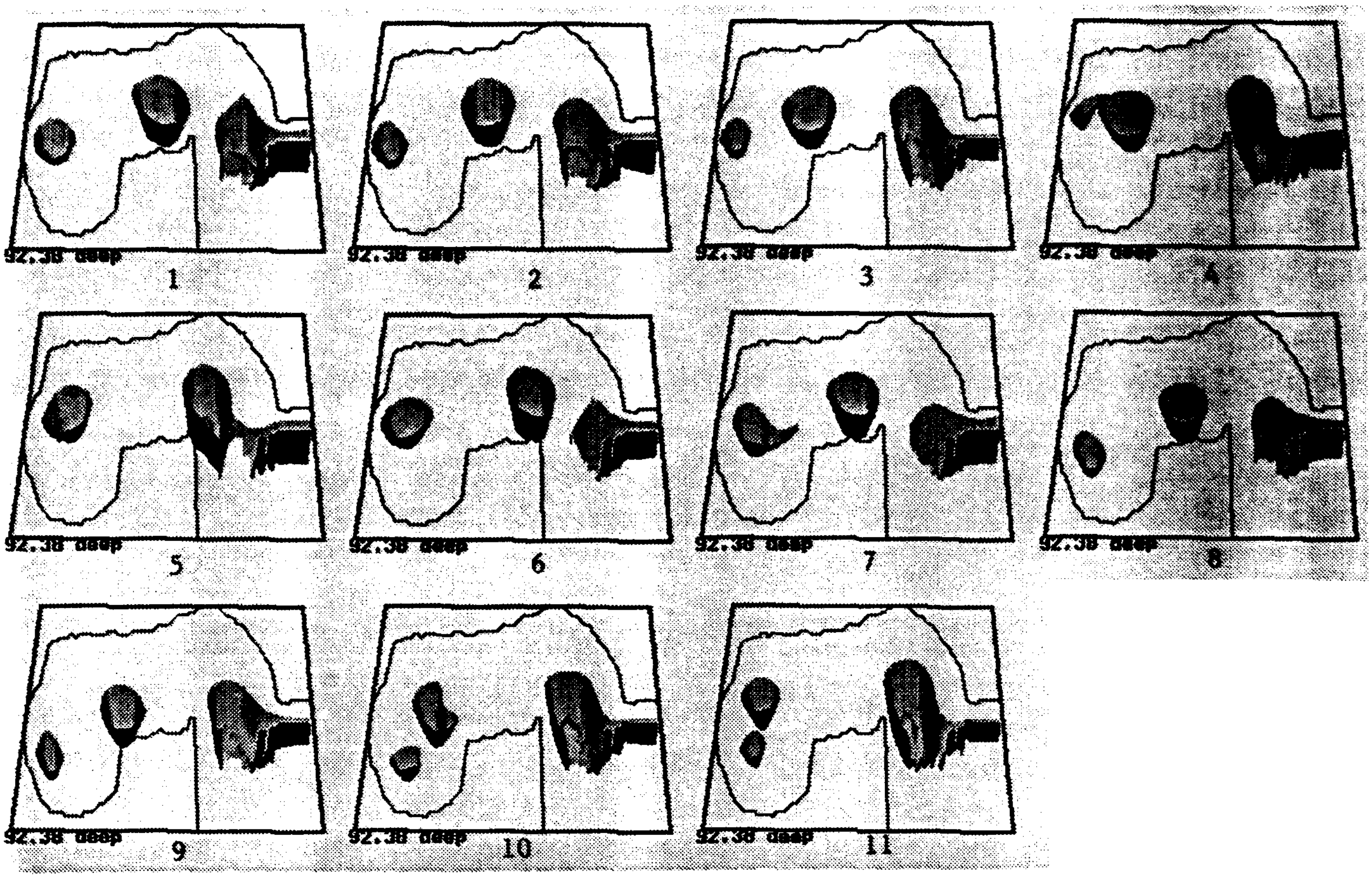

Figure 2.

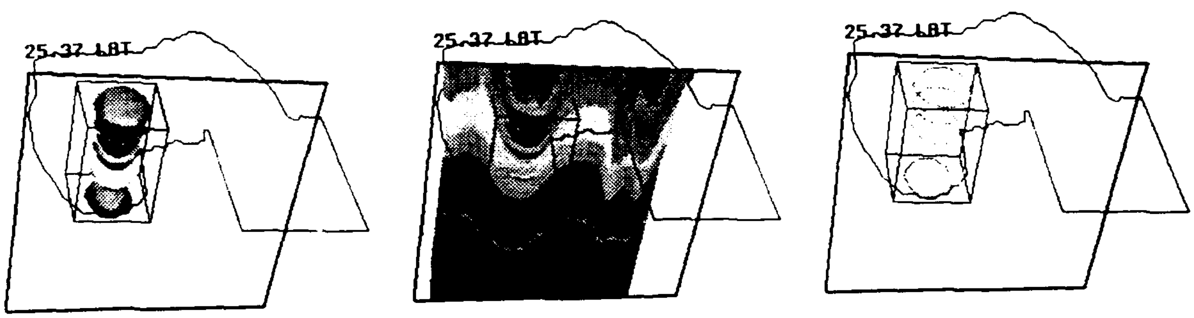

Figure 3. Eddy contours at different depths: (a) isosurfaces, (b) isosurface with overlaid vertical cutting pane, (c) contour lines.

The feature extraction has proven to be very useful in oceanographic visualization. The methodology developed applies not only to eddies but other ocean features as well.

Future Research: Further research will be directed at enhancing the accuracy and efficiency of the searching algorithms especially with scheme two and developing an associated surface fitting algorithm to best use the edge values.

Research Advisor: Dr. Robert Moorhead, MSU Engineering Research Center

Chandrashekar Ramanathan
Ph.D. Program, Department of Computer Science
Mississippi State University

TITLE: Object-Oriented Access to Geophysical Data

OBJECTIVE: The objective is to develop a prototype system that demonstrates the advantages of using an object-oriented model for large quantities of geophysical data that various modelers and scientists are storing in the Navy Environmental Operational Nowcast System (NEONS) using a relational database management system (RDBMS). The prototype will have the capability to validate the object model developed for grid-type data by allowing applications to be developed on top of the object-oriented layer.

APPROACH: The first approach is to develop an object model for the data and implement the model using an object-oriented database management system (OODBMS). The second is to continue using the data available in the RDBMS while providing transparent object-oriented access to that data. To use the enormous amount of data already present in NEONS, we chose to provide only an object-oriented view of the data rather than developing an OODBMS from scratch (Figure 1). For this, we developed an object-oriented schema for a portion of the NEONS database, and mapped it to the existing relational schema.

As shown in Figure 1, the application programs access the relational database in a transparent manner using ONEONS as a blackbox. One of the programs that was developed on top of ONEONS is an X windows-based user interface that relies on the object-oriented schema of the database.

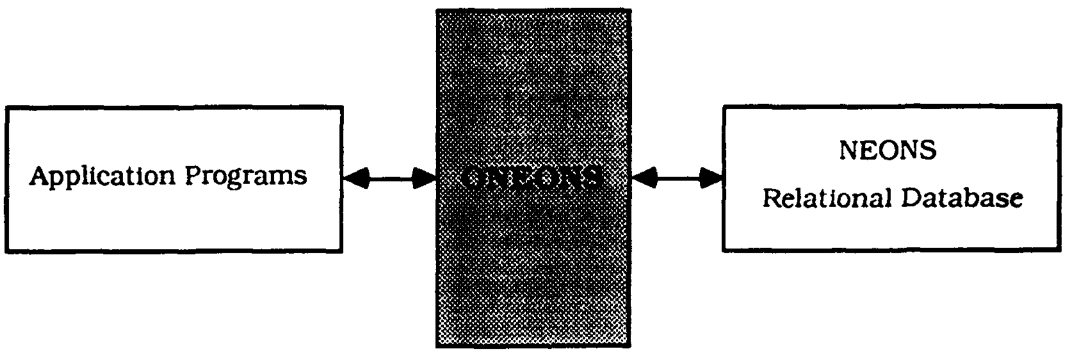

Figure 1. Object-Oriented Layer

The implementation of ONEONS is in the C++ programming language. Presenting a layering on top of a RDBMS requires a mechanism to access the relational data. Empress® has a precompiler that compiles code containing embedded SQL statements within C programs but not within C++ programs. Since ONEONS is being written in C++, an indirect mechanism is adopted to access the relational data by calling C routines that contain embedded SQL from C++ routines as shown in Figure 2.

The ONEONS Core is the heart of the system implementing the functionality of a limited object database tailored to the geophysical data domain. The design of ONEONS Core is driven by the structure suggested by Premarlani et al. in 1990. The fundamental unit of ONEONS Core is called a *section,* which is a database unit that can be loaded into memory and saved into the database as a single operation. All application programs work only with sections of objects, which are first loaded into memory. Therefore, all interactions of application programs take place within memory sections, thus avoiding the database input/output overhead with repeated

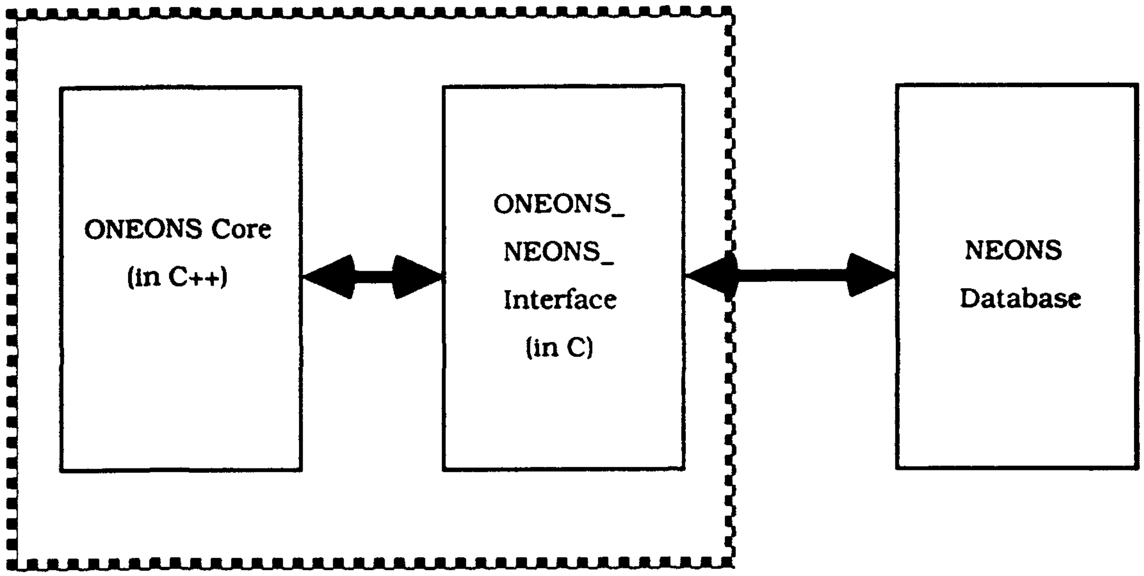

Figure 2

database access. Each object in a given section can be in one of the 5 states: transient, persistent, delete, insert, and update. ONEONS Core does not intend to build up a generic object-oriented database management system. It would provide object management for specific sections of objects belonging to the ONEONS schema.

The NEONS database contains data belonging to four conceptual data types: grid, image, lat-lon-time, and line. Presently, ONEONS contains object-oriented schema for the grid data type. Rumbaugh's OMT notation is used for drawing the object diagrams.

Results: The object-oriented schema for the grid data type was implemented with the limited functionality of data storage, deletion, and retrieval of all data except those in the primary realm. This layering was tested by developing an X-Windows based user interface on top of ONEONS for retrieval of descriptive grid data. The smaller amount of effort involved was clearly evident in developing the specific routines needed for that application using the primitives provided by ONEONS.

Future Research: Future efforts could proceed in several directions. The current involvement in accessing the data through the relational database could be eliminated by opting for a total object-oriented solution. This would involve selecting an OODBMS and implementing the already developed grid object schema using that system. This can be repeated for the other data types. Building a system that helps the users in identifying automatically what is useful and interesting is another active research area, knc n as knowledge discovery. Also, the efforts in building and implementing the object-oriented data model complements the knowledge discovery work because the meta structures needed for knowledge discovery can benefit by using such a data model.

Research Advisor: Dr. Julia Hodges, MSU Department of Computer Science

Dongmei Wu
M.S. Program, Department of Computer Science
Mississippi State University

Title: A Window-Based Intelligent Interface for Defining Descriptive Data in the Navy Environmental Operational Nowcasting System (NEONS) Database

Objective: To design and implement a window-based intelligent interface that allows NEONS users to define new descriptive data without consulting a database administrator. The design is based on the assumption that the user is well acquainted with the data to be stored but is not necessarily knowledgeable about the details of the NEONS database structure.

Approach: The first task was to become familiar with the NEONS database structure and determine which new descriptive data definitions a NEONS user would need to enter before ingesting data. This information was obtained from documentation of the NEONS database, data ingest requirements for grid data, and from discussions with CAST personnel.

The major goal was to design an interface that closely reflects the views of NEONS scientific users. Several ocean modelers were interviewed to obtain their views of the data and these views were mapped to the NEONS database structure. Instead of designing an interface that reflects the current NEONS relational database structure, the interface was designed to reflect the object-oriented view of the data that had been developed by Dr. Julia Hodges and Mr. Chandrashekar Ramanathan. The interface was designed according to the following:

- The functionality of each window should be obvious to the user, and the prompts on each window should be easy to understand. A help button should be available to allow the user to obtain additional information about the actions that can be preformed in each window.

- A consistent structure for each window should be maintained. For example, the basic structure of each window was designed to follow the same format, and the function keys were implemented in a consistent manner.

- Instructions, error messages, and notifications of actions should be displayed in a message area located near the bottom of each window.

- The depth of the window hierarchy should be minimized.

- The user should be able to select, modify, and delete previously entered data before definitions are stored.

- The user should not be asked to supply values that the system can calculate from previously entered values.

- The user should be prompted for inputs in a form that is meaningful. It should not be necessary for the user to consult with a database administrator.

- The user should be able to enter all data types currently supported by the NEONS database.

- Constraints on valid data input should be communicated to the user. When possible, the user should be asked to choose an entry from a list of legal entries. In cases where the user enters the data, the format and the legal value range of the data should be presented in the message area.

Results: Our interface was integrated with the Browser which is currently being used as a CAST tool for NEONS. There is now an option ENTER NEW DATA to be added to Browser. When selected, choices for entering grid, llt, line, and image data are displayed. All of the work to date has used the NEONS grid data type.

If the user chooses grid data, a window named Grid Data is displayed. In this window, an area displays any data definitions the user has entered. The user can define data by selecting in any order from five buttons: Define Region, Define Model Type, Define Geometry, Define Grid Parameter, and Define Level. To avoid the user's opening too many windows at a time, once a button is chosen, the other buttons cannot be selected.

There are three common action buttons at the bottom of each data entry window: Ok, Cancel, and Reset. These allow the user to keep the entered data as a portion of the new data definition (by pressing Ok), abort the current data entries (by pressing Cancel), or clear the current entries (by pressing Reset). The user is allowed to keep the entered data by choosing the Ok button only if the required information has been entered.

For the Region and Model Type windows, the user can either select a region or model type from a list of the data already defined in the NEONS database or enter a new region or model type definition.

The terms used in the Geometry window mirror the modelers' view about the domain rather than the database structure (see Figure 1). For example, in NEONS, grids are classified as either Registered or Spherical Harmonic. Vertical Cross Sections are included under Registered grids for convenience even though they are not really in this category. In the interface, grids are divided into three categories that reflect the classification used by scientists: Horizontal Grid, Spherical Harmonic Coefficients, and Vertical Cross Section. As another example, the database terminology for specifying how grid data should be stored is not meaningful to scientists. Rather than using the database descriptions such as "-x in -y", this query is posed as Position of First Data Item and Storage Sequence. The prompts displayed in this window are dependent on the choices the user has selected.

The Grid Parameter window allows the user to define several parameters at a time by either selecting definitions from the list of data which has been previously defined in the NEONS database or by entering new definitions. If the grid parameter name the user has defined is the same as one already in the NEONS database and at least one of the values has been changed, a warning message will be displayed to notify the user to enter a new grid parameter name. The user is also able to modify or delete one of the data definitions that has just been entered.

The Level window has the same performance as the Grid Parameter window except that the user is only allowed to select levels from the list of data which has been previously defined in NEONS database.

Future Research: A long term goal is to construct an intelligent browsing tool responsive to user needs. The interface can be enhanced by associating it with knowledge discovery. The system can build a profile of the user and then use the profile to display the type of information the user is most likely to be interested in.

Research Advisor: Dr. Susan Bridges, MSU Department of Computer Science

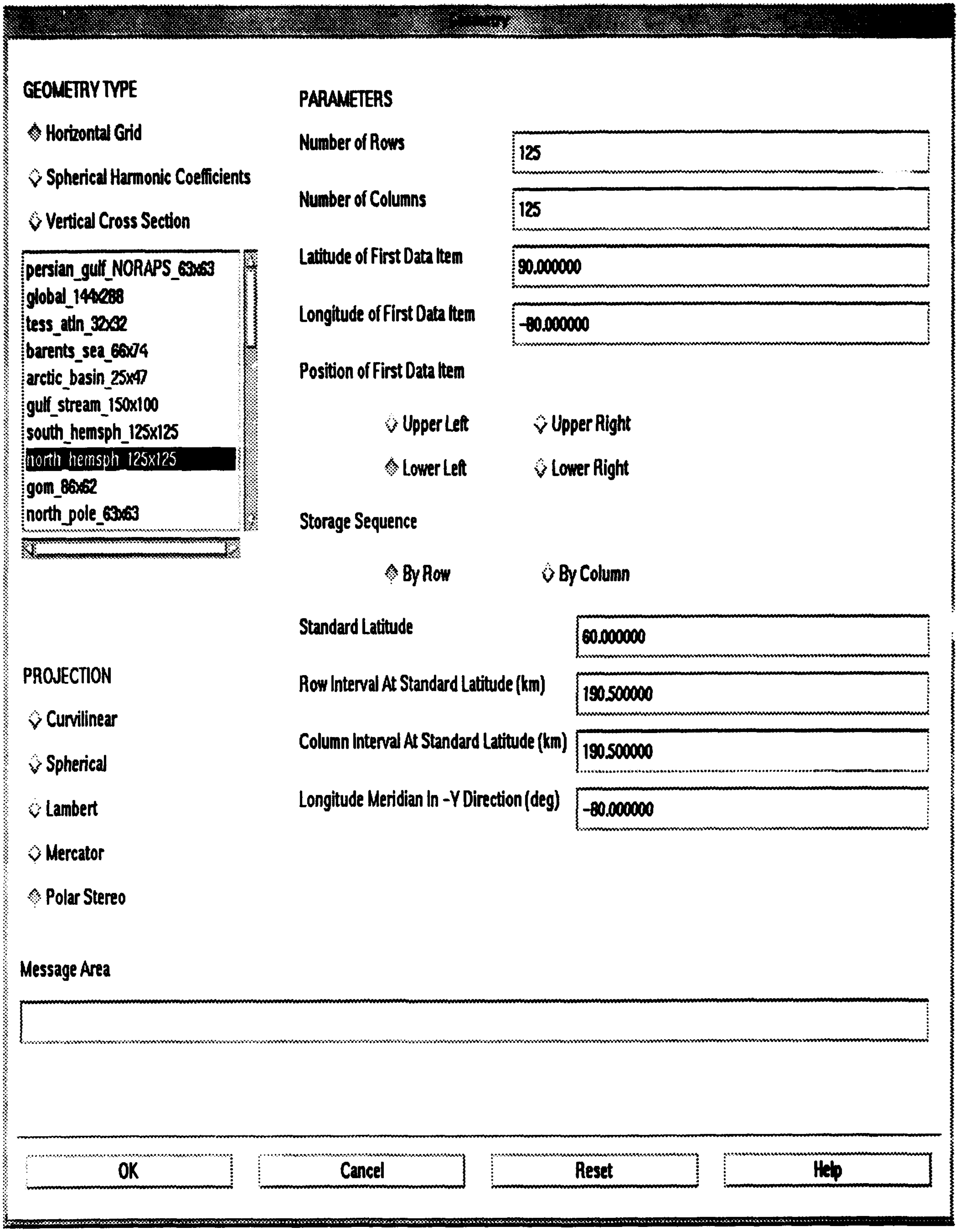

Figure 1. A Window-Based Intelligent Interface for NEONS.

Puli Suresh Rangabashyam
M.S. Program, Department of Computer Science
Mississippi State University

Project # 1 Title: Enhancing CMES Data Visualization Capabilities

Objective: To add a file reader to the CMES to visualize data resident in flat files.

Approach: The current version of the CMES supports functions to analyze and visualize data resident in the database. To access this data, various parameters such as model name, version name, level type, and parameter type must be set before the data can be retrieved from the database and be analyzed.

However, if the user wants to analyze data existing in a flat file, the CMES requires that the data be ingested into database before it can be analyzed. Hence the need to develop a tool to retrieve data from flat files.

Results: A utility called IMPORT was developed to provide a user with a graphical interface, where provisions were made for the user to enter the parameters to be set and the file where the data exists. This utility helps the user retrieve data from the flat file in a manner similar to data being accessed from the database. This allows the user to interact with data without having to ingest data into the database.

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Project #2 Title: The Addition of Database Administrative Tools to BROWSER

Approach: The BROWSER system is a high-level graphical user interface to browse and display information in the NEONS database. To maintain and manage this database, there was a need to add certain administrative tools to the BROWSER system that allows users not familiar with RDBMS technology to use the system without the assistance of a trained database administrator.

Results: Tools were developed to update the NEONS database using embedded SQL. This allows the user to query, update, and maintain the database without having to learn database query languages.

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Project #3 Title: Support for the Navy Interactive Data Analysis System (NIDAS)

Results: As part of NIDAS utilities, a graphical user interface using high-level OSF-Motif widgets was built. Assistance was also provided in the preparation of the NIDAS User's Manual.

Research Advisor: Mr. Ramesh Krishnamagaru, MSU CAST

Srinivas Bontu
M.S. Program, Department of Computer Science
Mississippi State University

Project #1 Title: Development of A Network Data BROWSER

Objective: At the request of the Naval Research Laboratory Ocean Dynamics and Prediction Branch, CAST was asked to develop a Network Data BROWSER that allows users to browse and query geo-physical data files (which are scattered across the network) based on spatial and temporal coordinates. The Network Data BROWSER was developed using X-Windows/Motif for graphical interface and EMPRESS database management system.

Approach: The Navy collects a large volume of data about the ocean from various sources to conduct experiments and ocean simulation studies. The output of these experiments is generally spread across multiple systems on the network, and the volume is generally high and is in the order of several gigabytes. Several techniques are used to analyze the data and to run simulations, and these techniques are sometimes referred to as models. Each model may have several versions depending upon the physics, configuration, numerical scheme, or optimization techniques. A model may be used to conduct several experiments to analyze the ocean behavior by varying the tunable parameters, and the results of these experiments are stored across the network in the form of data files. Given this scenario, it is difficult for the user to keep track of all the data in the network and its related information. Hence, a relational database scheme to maintain information about these experiments was needed.

Results: The database schema established a relationship between the temporal and spatial coordinates and the physical data files. As a result, the user can now easily retrieve information related to experiments, models, and physical storage. To function, results of the experiments had to be registered with the database by the user to support browsing functions. The registered information includes the model name, version name, experiment name, geometry, parameters, and min-max times. The database also contained information about ocean/atmospheric model simulations, hindcasts, and predictions. Once the data is entered into the database, the Network Data BROWER allows the user to browse through the database. The user can ask various questions about the model and experiments. The user may limit his/her search to some combination of a particular set of model types, or a particular range of parameters specific to one model type, or a particular region, or a particular time frame.

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Project #2 Title: The Evaluation of Two Networking Paradigms to Support NETNEONS and NETBROWSER

Objective: To develop a data transfer prototype from one host to another, based on Remote Procedure Calls (RPC and Data Transfer Mechanism (DTM).

Approach: The first task was to become familiar with RPC calls and the stub generator which adds stub around the procedure calls to support networking. An initial client/server prototype was developed using RPC functions and data was transferred from one host to another. Another client/server prototype using DTM was developed to perform the same function. DTM is a networking application programming interface (API) built on top of UNIX sockets. DTM was developed by the National Center for Supercomputer Applications (NCSA) and is tailored to support scientific data set transfer through UNIX ports.

Results: The DTM prototype performed faster relative to the RPC-based solution. The DTM-based solution was much easier to program and provided a good base to develop an API on top of the DTM specific to our needs. This was important because NETNEONS needs to support all functions in NEONS (RDBMS-based Data Model) which means that several data types such as Grid, Observation, Images, and Coastlines need to be read/written from/to the remote machine. Hence, the DTM-based solutions promoted reusability and extensibility, in addition to the ease of programming and relatively better prerformance.

Research Advisor: Mr. Ramesh Krishnamagaru, MSU Center for Air Sea Technology

Lakhamraju Ramakrishna
M.S. Program, Department of Engineering
Mississippi State University

Project #1 Title: Graphics Support for Ocean Modeling

Objectives: To develop an animation program for ocean models used by CAST and to provide video/audio recordings for presentations.

Results: Based on the Fortran code developed by Dr. David Dietrich, a code was rewritten in C for the animation of horizontal temperature cross-sections in the Gulf of Mexico. New sections were added to read the raw data of the vertical cross-section and to display color-fill contours of the temperature field. The animation of both displays was done synchronously for a one year run. The program was not interactive. The top window displayed the horizontal cross-section, with land, latitudinal cross-sectional line, and titles for identifying countries/states. The bottom window displayed the vertical cross-section as represented by the white latitudinal line in the top window. The program had the capability to record the animation automatically on a laser disk. Several video recordings were produced and demonstrated at The Oceanography Society meeting in Seattle in April 1993.

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Project #2 Title: Two-Dimensional CAST Ocean Visualization System

Objectives: To develop a generic ocean visualization program for datasets commonly used at CAST and Naval Oceanographic Office utilizing the high-end visualization capabilities of a Silicon Graphics Incorporated (SGI) graphics processor.

Results: A prototype Motif-based single 2D display of ocean data was developed by MSU's Dr. Robert Moorhead and graduate student Mr. Zhifan Zhu. This program was significantly modified to meet the needs of CAST. Modifications included performing synchronized spatial and temporal animations in both display windows. The system also did synchronized eddy tracking in ocean data. Figure 1 displays six images of an animated sequence of two synchronized windows for eddy tracking. Window 1 is the horizontal cross-section of the temperature field with the cross-hair at the eddy center. Window 2 is the vertical cross-section at the latitude of the eddy center represented by the cross-hair. There are contour and colorfill options for rendering, which can be done independently on both displays. Setting the color palette and contour minimum and maximum levels can also be done independently. This system uses a 2D edge-based feature extraction algorithm to display ocean eddies. Shown in Figure 2 are six images of the spatial animation of eddy vertical structure.

Future Research: The program was developed for eddies, but can be extended for fronts and other mesoscale features. Adding more tool boxes for additional features is a logical extension.

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Project #3 Title: Integration of the Ocean Visualization Interactive Research Toolkit (OVIRT 2.0) into the CAST Model Evaluation System (CMES)

Objective: To provide for 3D interactive visualization by integrating OVIRT 2.0 into the CMES.

Results: Both CMES and OVIRT data structures were studied to develop an interface program to dump relevant data into OVIRT data structures. The Motif-based OVIRT 2.0 served as an application shell of CMES. Accordingly, OVIRT 2.0 could then be run by selecting data using CMES. In addition, the former way of accessing data from files was retained. Three cross-lines were introduced into the cutting plane rendering to enhance the visibility of edges at plane intersections.

Future Research: Several enhancements can be done to enhance OVIRT 2.0 that include contour rendering in 3D, vectors and particle traces, and finding a method to overcome the bathymetry overlay problems.

Research Advisor: Dr. Harsh Anand, MSU CAST

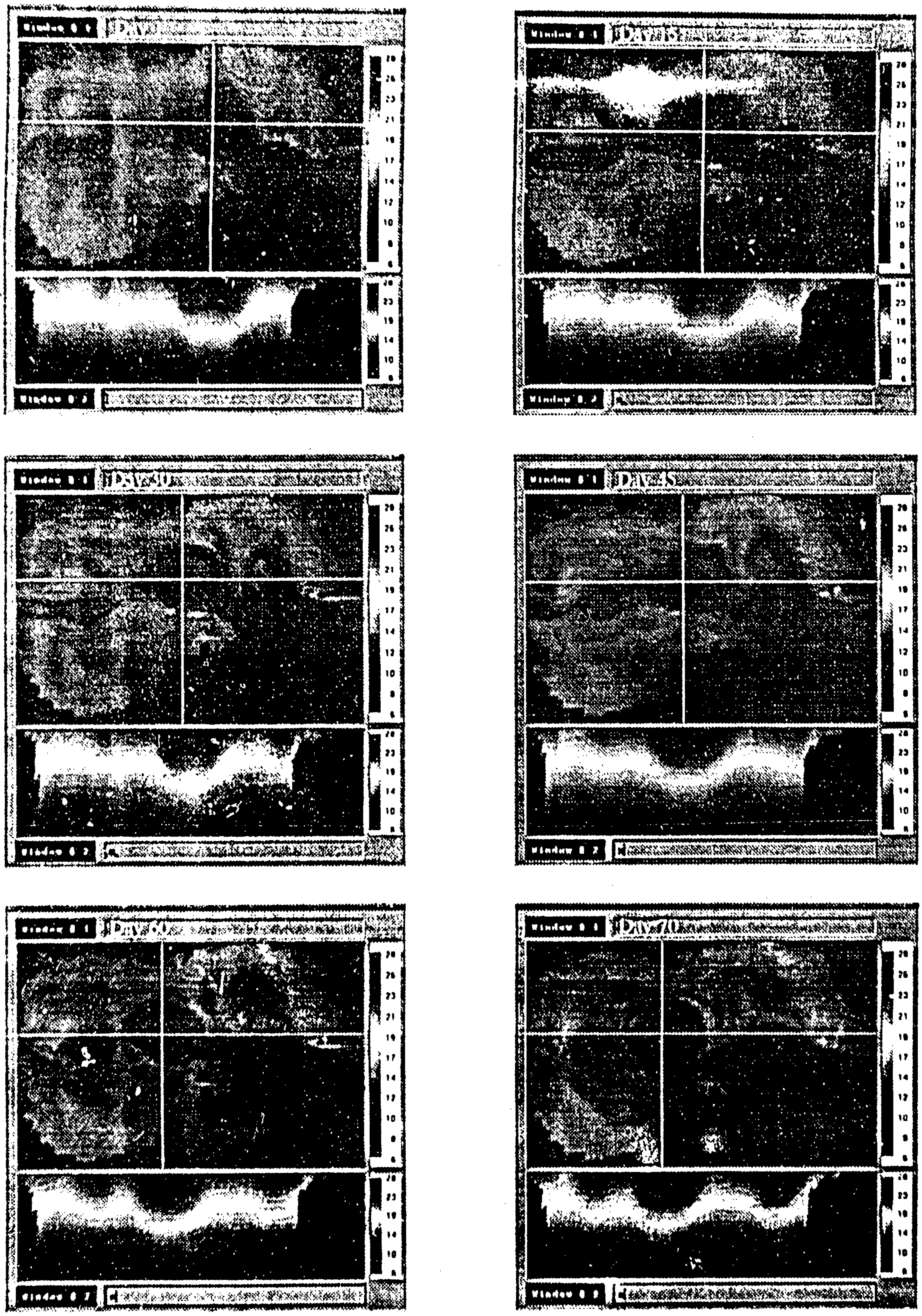

Figure 1. Six images of an animated sequence of two synchronized windows for eddy tracking. Window 1 (upper) is the Horizontal cross-section of the temperature field with the cross-hair at the eddy center and window 2 (lower) is the vertical (xz) cross-section at the latitude of the eddy center represented by the cross-hair.

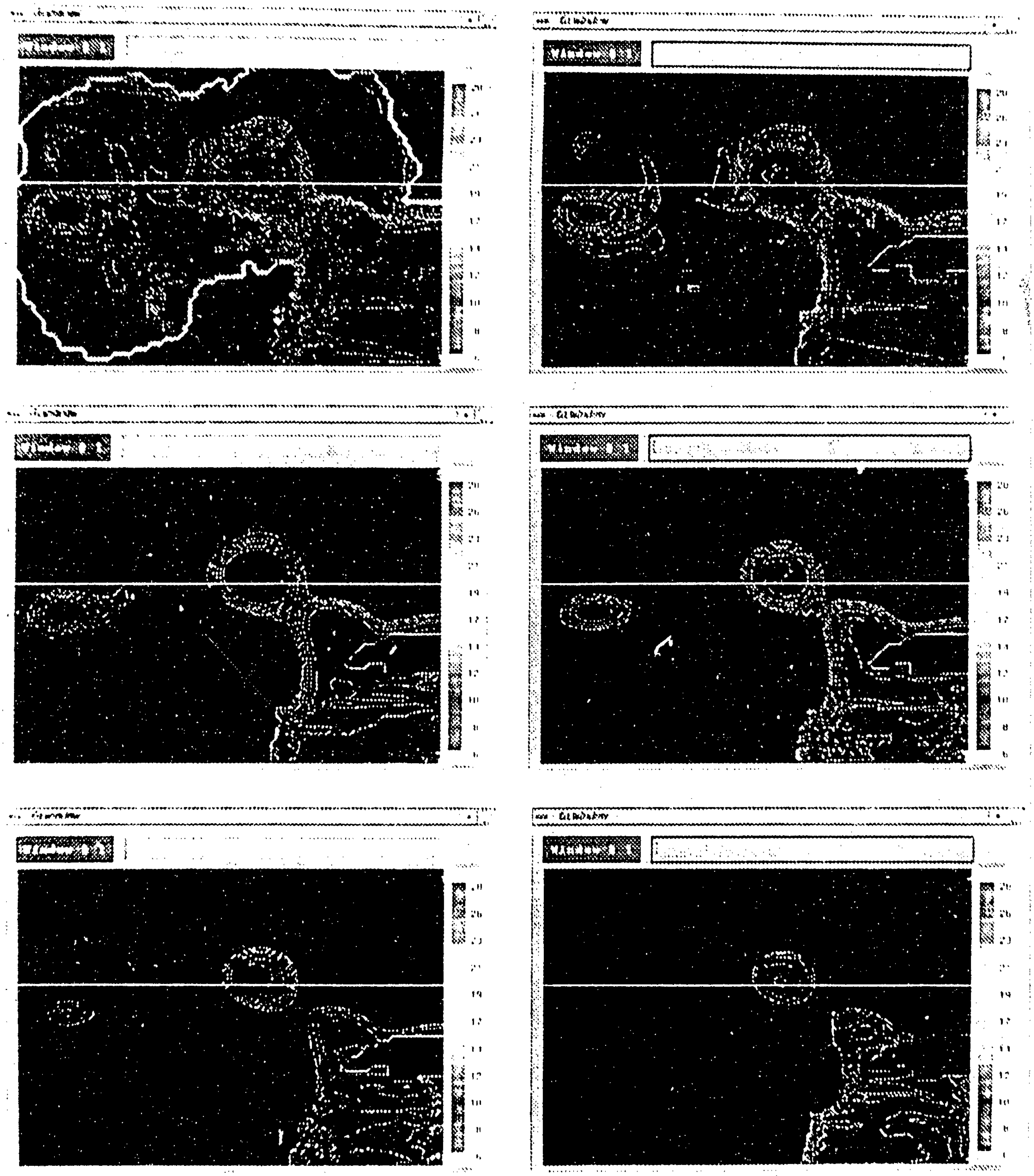

Figure 7. Six Images from a Spatial Animation of Vertical Levels Through Eddy Structure

Mark Henry
B.S. Program, Department of Engineering
Mississippi State University

Project #1 Title: A Relocatable 2D Tidal Model

Objective: To develop the graphical software to relocate the Colorado University Tidal Model to any given region/sea in the world.

Approach: The initial effort was to learn adequate skills in X-Windows/Motif programming and to write a data conversion/export filter in C to read and write a tidal components station data file for the model initialization data. The data formats were pre-specified. The work involved understanding the basic ocean tides, the forcings of the various components, and the dataset format. The original FORTRAN format specifiers were converted to appropriate C format specifiers. After that there was a need to understand the C data structure to initialize, load (read data into), and unload (clear and free memory) the data structure.

The second effort was to develop a graphical user interface (GUI) to tag and edit the individual station data components. The GUI was built in the X-Windows system using the OSF Motif toolkit. The task was to design the interface and the specific functions and callbacks for each widget. The user must be able to tag each station to be included or excluded in the final assimilation process of the model. Similarly the user must be able to include or exclude specific tidal components for the given station. The user must also be able to manually edit the component data value to correct inappropriate values. After the GUI was built, the design process was reiterated, with user feedback and callback functions added.

Results: The modules have been incorporated into the tidal modeling software. The user does not have to be concerned about the file format for the tidal station data. Furthermore, one is able to edit the data graphically, and browse the data quickly simply by selecting the station from a geographical map. This feature has shortened the set-up time needed for the model in a new region.

Research Advisor: Mr. Valentine Anantharaj, MSU Center for Air Sea Technology

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Project #2 Title: A Color Palette for Volume Rendering

Objective: To design a color palette for volume rendering using X-Windows.

Approach: Volume rendering uses many colors for lighting and shading, and it is important to keep enough colors so that the display does not look dithered. However, the software must be intelligent enough to use the 24-bit plane of the hardware.

Results: Software allocating color table interactively was developed and incorporated in CMES.

Research Advisor: Mr. Ramesh Krishnamagaru, MSU Center for Air Sea Technology

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Project #3 Title: MOODS Database Management System (MDBMS)

Objective: At the request of the Naval Oceanographic Office, CAST was tasked to incorporate changes into the Master Oceanographic Observations Data Set (MOODS) DBMS.

Approach: Several changes including titles of plots, legends and fonts, date/time format, graphical user interface look and feel, and cursor change to indicate busy state were requested. This involved working with MOTIF and UNIRAS software.

Results: The requested changes were incorporated and demonstrated to Navy users.

Research Advisor: Mr. Ramesh Krishnamagaru, MSU Center for Air Sea Technology

Atchuta Bontu
M.S. Program, Department of Engineering
Louisiana Technological University

TITLE: Client/Server Model to Access a Database Across the Network

OBJECTIVES: To develop a client/server model with a library of routines needed to access a database across a network. This circumvents the need for remote sites to purchase the Empress relational database management system (RDBMS) software which performs networking functions on the client side to access the remote database. This also allows users to access databases that employ other database engines such as Oracle, Sybase, Informix, or Ingres.

APPROACH: To implement the client/server model, a data transfer mechanism (DTM) library developed at the National Center for Supercomputing Applications was used. DTM is a message passing facility between two hosts. Using DTM, sophisticated distributed applications can be created. DTM provides a method to interconnect applications at run-time, with reliable message passing, synchronization, and transparent data conversion. A DTM port is a unidirectional synchronized communication channel through which DTM messages may be sent or received. All messages are exchanged through the DTM ports using TCP/IP communication. These have been implemented on UNIX machines on top of Berkeley sockets. Each DTM port corresponds to one TCP/IP connection.

Using client/server principles, the client (remote user) was able to access databases residing on remote machines. The server runs on the machine where the physical database resides. The client establishes the network connection with the server. The database server makes use of NEONS software to perform requested operations such as retrieving, deleting, storing, and updating the data. This makes the location of the database transparent to the user. This client/server model allows a client to interact with the server which performs NEONS services on the database and passes the results over the network to the client.

The client program uses DTM to accomplish networking functions. It transforms the user's NEONS calls (such as database open, database close, read llt data, write llt data) and associated arguments into DTM messages and sends these messages to the server through DTM ports. The server on the other end receives the DTM messages, transforms them into the database NEONS calls, and uses NEONS software to perform the requested operations on the database. The retrieved information is then sent back to the client by the server in the form of DTM messages. The client then transforms the received messages into the database parameters and values and passes them to the user application.

RESULTS: This model was satisfactorily tested using GUI tools called BROWSER and IDEAS. The performance was also good compared to accessing the database using Empress software. Software license restrictions and the cost of database maintenance/access have now been eliminated. Oceanographers can use this client/server model to access any database across the network that uses NEONS software, for initializing and validating ocean models, or to conduct simulations.

FUTURE RESEARCH: To improve the performance of client/server model, optimization can be done in several ways. The primary function of the server should be performing database operations only. The server should be relieved of packing and unpacking the data. The client should do the processing for packing and unpacking the data.

Research Advisor: Mr. Ramesh Krishnamagaru, MSU Center for Air Sea Technology

LeAna Dusang
M.S. Program, College of Science and Technology
University of Southern Mississippi

Title: Database Applications and Their Documentation

Objective: The objective was to acquire knowledge of database models and how they are integrated into applications. Once this knowledge was acquired, the problem was to prepare documentation (users manuals and design documents) for applications that incorporate database technology. The work required testing and evaluation of application functionality to ensure that design specifications were correctly implemented. It also included preparation of all graphics required to illustrate the documentation.

Approach: The database studied to gain insight into data models and database operations was the Naval Environmental Operational Nowcasting System (NEONS) developed at the Naval Research Laboratory, Monterey, California. NEONS, a relational database model built upon the Empress relational database management system (rdbms), is used to store oceanographic and atmospheric data. Structured Query Language (SQL) commands to the rdbms have been embedded within C and Fortran functions/subroutines that make up the NEONS Application Programmer Interface (API) library. Programmers can write applications that ingest and retrieve data and perform database queries on NEONS database by integrating NEONS API routines into their software code. NEONS familiarization involved system installation as well as data ingestion and retrieval using NEONS API functions, subroutines and shell scripts. CAST has developed several scientific applications that employ NEONS to manage their data, such as the CMES, the NEONS Browser, and IDEAS. These applications were studied in detail, before embarking on the final phase of the project.

Development of two new applications at CAST provided the opportunity to apply the acquired database and database applications knowledge toward production of documentation. Users manuals and design documents for these applications - the Naval Interactive Data Analysis System (NIDAS) and the Master Oceanographic Observation Data Set (MOODS) Software System - were prepared in accordance with Department of Defense (DoD) Military Standard (MIL STD) 2167A. This standard prescribes the format and content for all required software documentation items produced by or for the DoD.

Preparation of design documents and users manuals requires close collaboration with the software engineers and programmers who write the software code. The textual content must adhere to the standard. Each software module within the application must be described in detail in the design document. Each functional feature of the application must be described, along with examples, in the users manual. In both documents, graphical depiction of monitor screen content must be used to illustrate the written text. Finally, the printed document must be professional in its quality and thoroughness.

Results: Detailed knowledge of database design and operation has been acquired through hands-on experience. An understanding of documentation requirements has been achieved. NIDAS and the MOODS Software System are now properly documented in accordance with the relevant DoD standard.

Research Advisor: Mr. Michael S. (Steve) Foster, MSU Center for Air Sea Technology

Clifton Abbott
B.S. Program, MSU Cooperative Education Program
Mississippi State University

Project #1 Title: Tactical Oceanography Wide Area Network Export Grid

Objectives: To develop a grid function to export grid data from within the NEONS Browser.

Approach: Export grid works on a region that the user selects and passes into the function along with other necessary information. The geometry is searched for all grid data points within the selected region. When found, the data value is retrieved for each point. An export file is then created with a header that includes the southwest and northeast corners of the grid data, the model type, the geometry name, parameter name, and the level type. Then the latitude, longitude, and the data value is printed with the southwest corner being the first data point and the northeast corner being the last.

Results: The export grid function was completed, tested, and integrated into the NEONS Browser.

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Project #2 Title: Network Data BROWSER

Objectives: To develop a network data browser using X-Windows/Motif and the EMPRESS DBMS that allows users to browse and query information found across the database.

Approach: The Browser prototype, developed by Mr. Srinivas Bontu, was significantly modified to allow the user to query information about experiments and their data, to search for specific experiments given certain data, and to add new entries into the database.

Results: The X-Windows/Motif-based browser was developed so the user could browse, query, and search experiments and the data found within the experiments. The user can now add new models, versions, parameters, experiment levels, tunable parameters, and update experiments without having any real knowledge of the tables within the database. Clients can run this browser from any machine, have access to the database, and do not need an account on the machine on which the database is stored.

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Project #3 Title: The Database Duplicate Identifier

Objectives: To develop a method to identify duplicate information within the MOODS database and to delete unnecessary duplicates.

Approach: Given a database table, the approach was to develop a program to search each entry and send all duplicate entries to a file. The user then edits the file to include only the entries to be saved. All other entries will be deleted with the wanted entries re-inserted into the database.

Results: The Database Duplicate Identifier was created and now functions as a tool to eliminate unnecessary duplicate information within the MOODS database.

Research Advisor: Mr. Ramesh Krishnamagaru, MSU Center for Air Sea Technology

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    -Mr. Clifton Abbott

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    -Mr. Lakhamraju Ramakrishna
    -Mr. Mark Henry

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    New Orleans, LA 70118
    -Dr. Fred Petry
    -Mr. Patrick Perrin

13. Department of Engineering
    Louisiana Tech University
    Ruston, LA 71272
    -Mr. Atchuta Bontu

14. College of Science and Technology
    University of Southern Mississippi
    Hattiesburg, MS 39401
    -Ms. LeAna Dusang

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REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. Agency Use Only *(Leave blank).*

2. Report Date. 31 DECEMBER 1993

3. Report Type and Dates Covered. TECHNICAL NOTE

4. Title and Subtitle.

1993 STUDENT RESEARCH PROJECTS

5. Funding Numbers.

Program Element No.

Project No.

Task No.

Accession No.

6. Author(s). P. PERRIN, F. PETRY, R. MOORHEAD, Z. ZHU, J.HODGES
C. RAMANATHAN, D. WU, S. BRIDGES, P. RANGABASHYAN, H. ANAND
S. BONTU, R. KRISHNAMAGARU, L. RAMAKRISHNA, M. HENRY,
A. BONTU, L. DUSANG, S. FOSTER, C. ABBOTT, AND L. YESKE (EDITOR)

7. Performing Organization Name(s) and Address(es).

MISSISSIPPI STATE UNIVERSITY
CENTER FOR AIR SEA TECHNOLOGY
STENNIS SPACE CENTER, MS 39529-6000

8. Performing Organization Report Number.

CAST TECHNICAL NOTE 02-94

9. Sponsoring/Monitoring Agency Name(s) and Address(es).

OFFICE OF NAVAL RESEARCH
800 NORTH QUINCY STREET
CODE 1242
ARLINGTON, VA 22217

10. Sponsoring/Monitoring Agency Report Number.

CAST TECHNICAL NOTE 02-94

11. Supplementary Notes.

RESEARCH PERFORMED UNDER THE OFFICE OF NAVAL RESEARCH CONTRACT/GRANT NUMBER N00014-92-J-4109

12a. Distribution/Availability Statement.

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

12b. Distribution Code.

13. Abstract *(Maximum 200 words).*

Eleven 1993 student research projects were sponsored by the Mississippi State University Center for Air Sea Technology. This technical note describes these projects which include knowledge discovery for ocean modeling, scientific visualization enhancements, object-oriented access to data, intelligent interfaces for defining data, data browsing, database administrative tools, graphics support for ocean modeling, the Ocean Visualization Interactive Research Toolkit, client/server model access, database applications and their documentation, tactical oceanography wide area network export grid, and database duplicate identifiers.

14. Subject Terms.

(U) Technical Note (U) Student (U) Research (U) CAST

15. Number of Pages. 23

16. Price Code.

17. Security Classification of Report.	18. Security Classification of This Page.	19. Security Classification of Abstract.	20. Limitation of Abstract.
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	